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Experimental Investigation of Averaged Heat Fluxes Densities of a Droplet

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Extended Abstract

Heat and mass transfer of a droplet is widely used in industrial and energy sectors. Such operations take place in various parts of technological process in a boiler house, for example: it can be used for cleaning flue gases [1], increase humidity of flue gas before a condensing economizer [2], etc. Although investigated object is the same, very different processes take place during injection of a water droplet. Heating or cooling, condensation or evaporation of a droplet can occur in the flue gases at different stages during technological processes. It all depends on the initial temperature of a droplet and its surrounding environment. This is not a new interest, the scientists have been studying processes of a liquid droplet for well over a century [3], however due to the mandating environmental requirements and in order to use organic fuel more efficiently [4] applications of liquid spraying in thermal energy, especially in biofuel technologies, determines the continued interest in the processes of heat and mass transfer in the droplet [5].

This study is intended for experimental investigation of the intensity of phase transformation and heat transfer processes in a water droplet. In the test section of the experimental set-up the single water droplet was suspended on the ball of the thermocouple and the supplied flow of atmospheric air was passed over it. The experiments were performed in various regimes while changing temperature of atmospheric air and by adding additional humidity into the flow. To reach the preferred temperature of supplied atmospheric air flow, consecutively connected heaters are used. A desired air humidification is ensured by using a vapor generator before experimental section to get an adequate mix of air and water vapour. During the experiments, the main observed parameters were the temperature and the size of the water droplet: the temperature of the droplet was measured every second with a thermocouple on which the droplet is suspended and a high-speed camera was used to record the size of a droplet. Also, ambient conditions (temperature, pressure, relative humidity) were measured and the impact of initial water temperature on heat and mass transfer of a droplet is evaluated. These experiments demonstrated that additional humidity content in the supplied air flow makes changes in variation of heated water droplet dimensions dynamics and has influence for phase change regimes. Based on camera records of the variation in the water droplet size occurring because of the heated flow of the atmospheric air, calculation model was made to compute averaged heat flux densities which act on the suspended water droplet in the air flow. The calculation results show that at different time moments the averaged phase transformations heat flux density of the heating droplet has different values and vector signs that define condensing, transit, and equilibrium evaporation regimes of the water droplet. The experimental investigation and calculations demonstrate that additional humidity and higher temperature of the atmospheric air flow intensifies the heat flux densities of the water droplet and as a consequence intensity of the droplet's phase changes increases.

References

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